AD NUMBER
AD311195
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Controlling DoD Organization: U.S. Army Electronic Proving Ground, Electronic Warfare Dept., Fort Huachuca, AZ.
AUTHORITY
Army Electronic Proving Ground ltr dtd 10 Jan 1980; Army Electronic Proving Ground ltr dtd 10 Jan 1980

AD NUMBER

AD311195

CLASSIFICATION CHANGES

TO

confidential

FROM

secret

AUTHORITY

31 May 1969 per Group-3, DoDD 5200.10 document marking

AD 311195

AD 311195

SECRET

USAEPG-SIG 920-72
JANUARY 1957
SUPPLEMENT NR 1
MAY 1957

[redacted] FINAL REPORT, OPERATIONAL EVALUATION OF ECM SET AN/MLQ-8(XL-2) [redacted] (PROJECT 33-38-0015)

EW SYSTEMS TEST
USAEPG-3
PHASE II
EQUIPMENT TEST
AND EVALUATION (U)

U.S. ARMY ELECTRONIC PROVING GROUND

FORT HUACHUCA, ARIZONA

MAY 1957

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USAEPG-SIG 920-72, Project 33-56-0013, Supplement 1 to "Final Report, Operational Evaluation of ECM Set AN/MLQ-8(XL-2)" (U), has been prepared by the Electronic Warfare Department and is published for the information of all concerned. Suggestions or criticisms on the form, contents, or use thereof, are invited, and recommendations may be submitted to the Commanding General, U.S. Army Electronic Proving Ground, Fort Huachuca, Arizona, ATTN: SIGPG-DCGO.

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ERRATA SHEET, USAEPG-SIG 920-72

Page 16. First paragraph, second line; the word "directly" should be deleted and replaced by "inversely."

ERRATA, USATPG-SIG 920-72

Page 58. Paragraph 1, 3d sentence "tactical" should read "tactile."

Page 59. Paragraph 4, add parenthesis at end of last sentence.

SUPPLEMENT I
FINAL REPORT, OPERATIONAL EVALUATION
OF
ECM SET AN/MLQ-8(XL-2) (U)
(Project 33-56-0013)

May 1957

Electronic Warfare Department
U.S. ARMY ELECTRONIC PROVING GROUND
Fort Huachuca, Arizona

- - -

Engineering Services
by
ARMOUR RESEARCH FOUNDATION
Contract Nr Da-36-039 sc-67463

FOREWORD

Supplemental tests 1 through 4 for the operational evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-2) were conducted in response to a request from the Commanding General, United States Continental Army Command. These tests determine (1) mutual interference of two AN/MLQ-8(XL-2) jammers and (2) mutual interference between the AN/MLQ-8(XL-2) jammer and communications systems. This report was prepared by the Electronic Warfare Department, U.S. Army Electronic Proving Ground, as a part of Project 33-56-0013 to supplement "Final Report, Operational Evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-2)," (U) USAEPG-SIG 920-72. It will serve as a guide in future design development and doctrine of tactical employment.

H. McD. BROWN
Col SigC
Chief, Electronic Warfare Department

ABSTRACT

The results of four operational field tests of the Electronic Countermeasures Set AN/MLQ-8(XL-2) are set forth to supplement the tests reported in Final Report, Operational Evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-2), (U) USAEPG-SIG 920-72. The supplemental tests are concerned primarily with mutual interference from the use of the AN/MLQ-8(XL-2) in close proximity to another AN/MLQ-8(XL-2) or to other friendly electronic equipment. Two AN/MLQ-8(XL-2) jammers employed for mutual protection interfere slightly with one another when sited 1,000 yards apart, but, at tactical ranges of 2,000 yards or more, no disability is indicated. The jammer must be separated from division-area grid communications by a distance of 1 mile to prevent disruption of teletype circuits. When the Radio Terminal Set AN/TRC-24 of a grid system is sited from 2 to 15 miles from the AN/MLQ-8(XL-2), it shares power in proportion to which lobe of the AN/MLQ-8(XL-2) antenna is affected by the interfering transmission. This power sharing prevents predetonation of VT fuzes, or effective AN/MLQ-8(XL-2) operation. If the AN/MLQ-8(XL-2) is kept 1/4 mile away from Radio Set Aircraft Radio Corporation (ARC) Type 12 used for voice communications, the interference, although perceptible, does not prevent communication.

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Section I. Introduction

1. GENERAL

Electronic Countermeasures Set AN/MLQ-8(XL-2) was field-tested at the U.S. Army Electronic Proving Ground (USAEPG) during the summer and autumn of 1956. The results of the tests are set forth in "Final Report, Operational Evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-2)," (U) USAEPG-SIG 920-72, as a part of Phase II, Equipment Test and Evaluation, of the USAEPG-3 program.

2. BACKGROUND

A doctrine of employment was developed whereby two jammers were to be employed simultaneously because the individual unit was shown in the tests of 1956 to be incapable of adequate self-protection against VT fuzes. It was necessary to verify this doctrine by a test to determine whether or not the two equipments operating as a pair for self-protection interfere with each other and thus reduce the effectiveness of the jamming. As it had previously been determined that two AN/MLQ-8(XL-2) jammers could be employed effectively with intervening ranges of 2,000 yards or more, the test of mutual interference of the jammer described in this report simulated a situation in which the jammers were only 1,000 yards apart with antennas beamed toward each other. Even under these unfavorable conditions, the mutual interference, although noticeable, is not of sufficient duration or of uniform frequency to reduce the effectiveness of the jamming.

In some previous tests of the AN/MLQ-8(XL-2), interference effects on nearby radio communications were observed. It was, therefore, necessary to determine how serious the effects were and the distances at which the effects were observed. Tests were also scheduled to determine the deterioration in VT-fuze jamming caused by the communication links sharing power with the AN/MLQ-8(XL-2).

Section II. Description of Additional Equipment for Supplemental Tests

3. RADIO TERMINAL SET AN/TRC-24

Radio Set AN/TRC-24 provides fm. radio facilities for voice, facsimile, and teletype transmissions in the usable frequency range of 100 to 400 Mc/s over an unobstructed line-of-sight path. The set transmits basebands in the frequency range from 250 to 68,000 cps. Telephone Terminal AN/TCC-7 contains three modem (modulator-demodulator) units, three subgroup modulators, the group modulator, the order wire, and the 68-kc/s pilot circuits that provide 12 channels of traffic signals and one channel of order wire signals. Each modem can accept four voice-signal modulations in the frequency range from 250 to 3,500 cps. Use of the AN/TCC-8 permits eight teletype channels to be put on one voice channel, which gives the equipment a total capability of 96 teletype channels. This type of communications system is used in existing division-area grid communications. A block diagram of a division-area grid-communications system diagram is shown in fig. 1.

4. RADIO SET ARC TYPE 12

Radio Set ARC Type 12 is a VHF unit, which operates over the frequency range from 118 to 148 Mc/s to transmit and receive crystal-controlled, am. voice signals. The set can be airborne or ground-based. When the set is ground-based, a whip antenna is used. This type of radio set is used near the front lines in a division-area grid communications system.

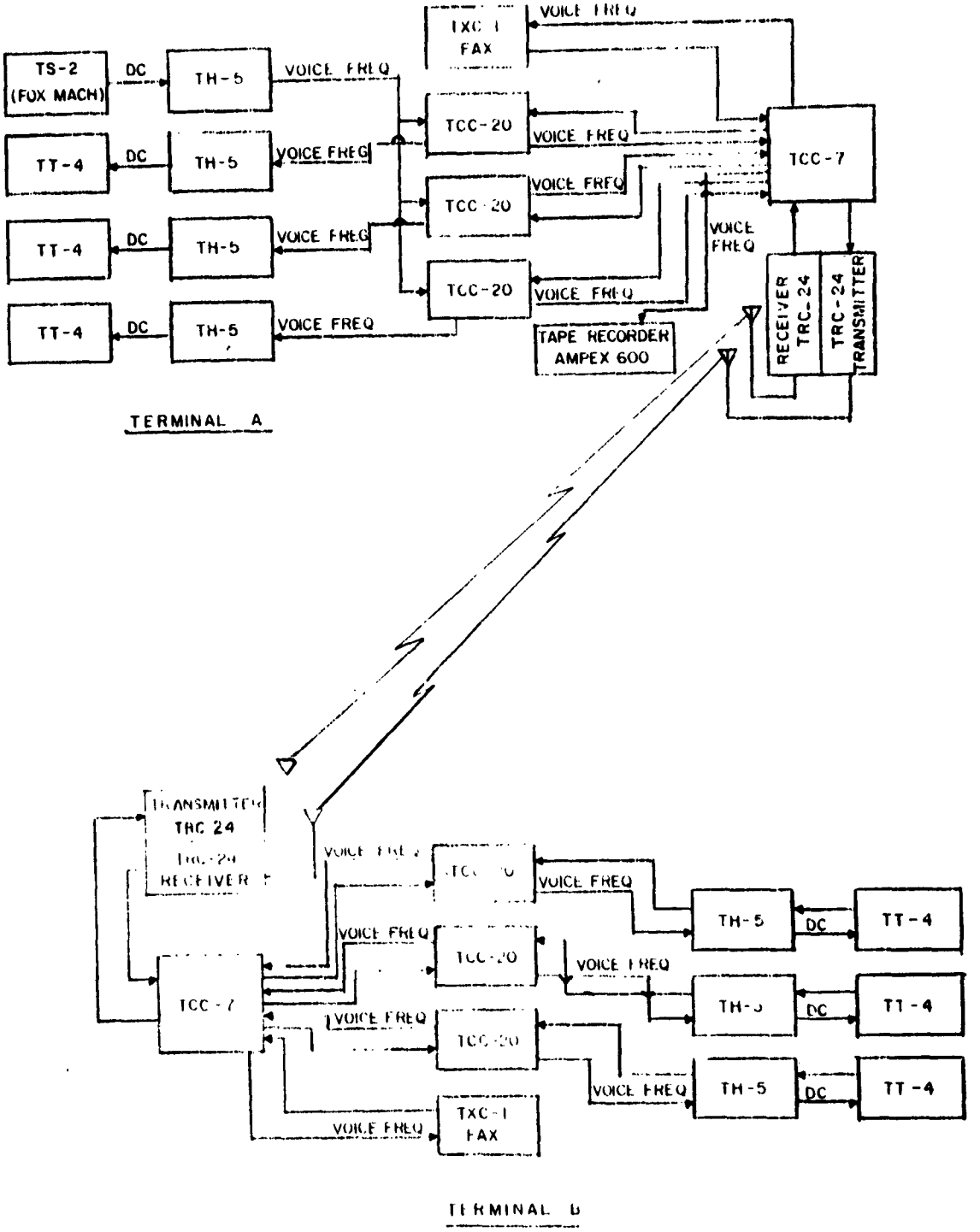


Fig. 1. Block diagram of division-area grid communications system

Section III. Supplemental Tests Performed

5. SUPPLEMENTAL TEST 1. MUTUAL INTERFERENCE OF TWO AN/MLQ-8(XL-2) JAMMERS

a. Purpose

The purpose of supplemental test 1 is to determine the degree to which two AN/MLQ-8(XL-2) jammers interfere with each other and reduce jamming efficiency when sited so that they face one another at a distance less than that at which the jammers had previously been tested.

b. Procedure

Two AN/MLQ-8(XL-2) jammers were sited 1,000 yards apart, facing one another. A Signal Generator 608C was used to feed a 160-Mc/s signal through an adjustable T-attenuator, 874-CA, to one of the jammers. Countermeasures Receiving Set AN/TLR-9 was used to monitor the output of the two jammers, each of which was adjusted to make two sweeps per second with a 1/5 duty cycle. The AN/TLR-9 was used in an attempt to synchronize the two AN/MLQ-8(XL-2) jammers, but variations in sweep rate made this impossible.

Tests were conducted under the following five conditions:

Condition (nr)	Jammer A (condition)	Signal generator at A (condition)	Jammer B, always on (squelch)
1	Off	Off	Off
2	On; squelch off	Off	Off
3	On; squelch off	On; freq. 160 Mc/s	Off
4	On; squelch on	Off	On
5	On; squelch on	On; freq. 160 Mc/s	On

c. Test Results

During condition 1, jammer B triggered on noise and swept from low to high frequency with an output between 10 and 15 watts.

During condition 2, an occasional large pip appeared on the scope of the AN/TLR-9 for a second or more when the jammers were synchronized.

Under condition 3, results similar to those obtained during condition 2 were observed. In addition, the signal of the opposing jammer could be seen on the receiver scope of each jammer. The signal moved from left to right, or from right to left, or remained stationary, because of the variations in synchronization.

During condition 4, when both jammers were operated with their squelch circuits on, triggering occurred only when an interfering signal of 178 Mc/s was received. The jammers did not interfere with each other.

Condition 5 yielded the same results as condition 3.

6. SUPPLEMENTAL TEST 2. EFFECT OF AN/MLQ-8(XL-2) OPERATION ON AN/TRC-24 IN A GRID COMMUNICATIONS SYSTEM

a. Purpose

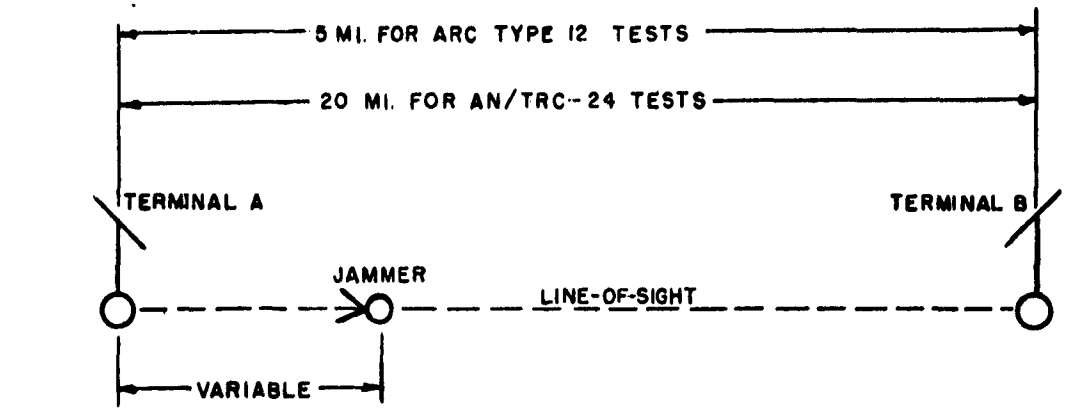
The purpose of supplemental test 2 is to determine the interference effects on communications when the AN/MLQ-8(XL-2) is employed in the vicinity of a division-area grid communications system and to determine at what distances or in what positions it could be employed without disrupting communications.

b. Procedure

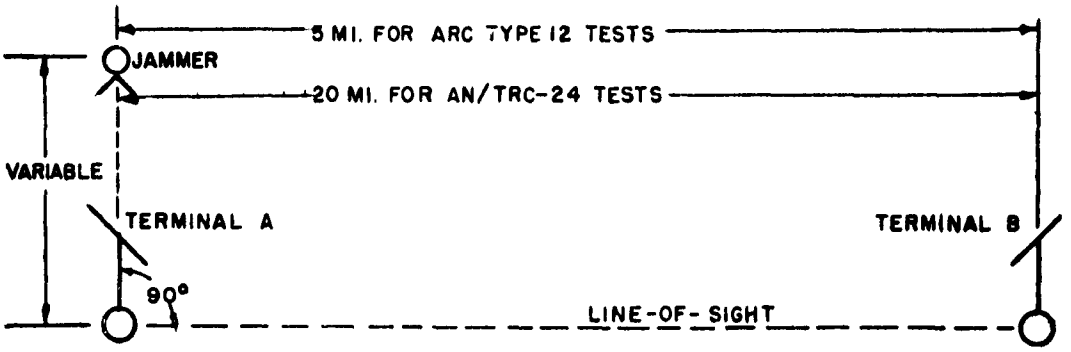
The grid communications system was composed of two AN/TRC-24 terminals sited 20 miles apart with a line-of-sight communications path as shown in fig. 2. The system had the capabilities of teletype, facsimile, and voice transmissions in both directions. As no on-line cipher devices were available at USAEPG for use in this test, the effects on these devices were not determined. The AN/MLQ-8(XL-2) was sited as shown in fig. 2A.

The distance from terminal A was varied and the effects of the jammer on the three types of communication were observed and recorded to the distance at which the effects of interference became negligible. During this step of the test, the antenna of the AN/MLQ-8(XL-2) was directed alternately at each terminal to note effects when the transmission of the AN/TRC-24 struck the back lobe of the jammer and triggered it to jam communications.

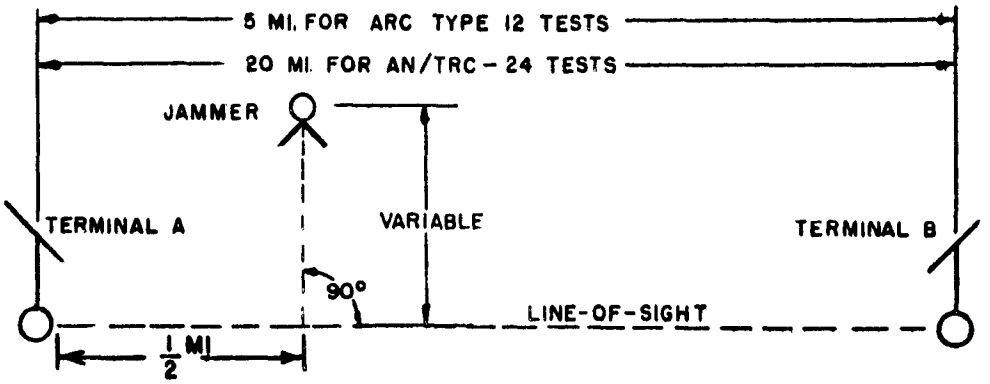
The positions shown in figs. 2B and 2C were also used in determining the interference effects with the jammer so sited that



A. JAMMER ON LINE-OF-SIGHT



B. JAMMER OPPOSITE TERMINAL A



C. JAMMER OPPOSITE POINT ON LINE-OF-SIGHT

Fig. 2. Siting arrangements for Tests 2 and 3

the main axis of its transmission intersected the line between the terminals at 90 degrees and at various points along that line. The frequency of the transmitter at terminal A was 134.25 Mc/s. The frequency of the transmitter at terminal B was 154.25 Mc/s. The jammer employed the EDL folded-dipole antenna elevated 10 degrees and polarized at 25 degrees and operated at maximum power. The AN/MLQ-8(XL-2) operated at 2 sweeps per second, and its duty cycle was 1/5. The squelch circuit of the jammer was turned alternately off and on to determine the effect of squelch-circuit operation on communications.

c. Test Results

With the jammer sited on the communications line-of-sight as shown in fig. 2A and with its antenna directed toward terminal A, all communications in both directions were satisfactory when the jammer was 1 mile or more from terminal A. A clicking noise at the sweep rate of the jammer was audible, but it was not intense enough to interrupt or disrupt voice transmissions. At the worst, it was irritating. The clicking noise appeared on all channels and on the order wire and could be heard as long as the jammer and the terminal were within 3 to 5 miles of each other.

When the jammer approached within a mile of a terminal with the jammer's squelch off, the teletype communications became garbled. When the squelch was turned on the communications remained garbled, although not so badly as before. When the squelch was at its maximum setting very little jamming occurred. An unexpected effect on the teletype transmissions was that when the teletypes were not transmitting any messages and the jammer happened to be on, a relay in the TH-5 rectifiers used in the communications circuit was thrown open, and the teletypes ran open at random. Different TH-5 rectifier units were substituted, and various degrees of the random teletype operation resulted. In one instance, the machines all ran open continuously, but in another, spasmodically. In still another instance the relay opened only partially and caused the teletype keys to flutter and jump intermittently.

The effects on facsimile were not considered serious. Dotted lines were produced by the jammer signal at intervals in proportion to the sweep rate of the jammer, but these lines were neither dark enough nor dense enough to obscure the transmission.

At a distance of 1 mile from terminal A the jammer antenna was turned around and directed at the B terminal to note the interference effects at A from the back lobe of the jammer antenna. The only effect was slight garbling of the teletype.

When the jammer was sited 1 mile off line-of-sight opposite terminal A as shown in fig. 2B, the effects were approximately the same as when it was on the communications line-of-sight. The jammer antenna was pointed only in the direction of the terminal.

When the jammer was placed 1 mile off line-of-sight at a point 1/2 mile from terminal A, the effects were approximately the same. At a distance of 1 1/2 miles, no interference was noted even with the jammer squelch off.

7. SUPPLEMENTAL TEST 3. EFFECT OF AN/MLQ-8(XL-2) OPERATION ON ARC TYPE 12

a. Purpose

The purpose of test 3 is to determine the interference effects on communications when the AN/MLQ-8(XL-2) was used in proximity to a VHF circuit that employs two units of ARC Type 12 separated 5 miles but with line-of-sight between them.

b. Procedure

The method employed in test 3 was the same as that illustrated in fig. 2 for test 2. The jammer was sited directly on the line-of-sight, then on a line at right angles to the line-of-sight at the point occupied by one of the ARC Type 12 units, and then on a line that is perpendicular to the line-of-sight and intersects it 1/2 mile from terminal A. The communication equipments, which were 5 miles apart, operated on a frequency of 132.82 Mc/s. The jammer employed the EDL folded dipole antenna elevated 10 degrees and polarized at 25 degrees and operated at maximum power. It operated at two sweeps per second with a duty cycle of 1/5 and with the squelch circuit turned alternately off and on.

Voice transmissions were directed from each radio set to the other radio set. The interference effects were observed for various distances from the AN/MLQ-8(XL-2) to the ARC Type 12 units, and for various distances from the line-of-sight and at orientations to it to determine the distances and positions at which the effects of interference became negligible.

c. Results

While the AN/MLQ-8(XL-2) was sited as shown in fig. 2A on the line-of-sight 1/2 mile from terminal A and 4 1/2 miles from terminal B, interference was uniformly negligible. At terminal B the jammer sweep was audible at all times, but, at terminal A, the sweep was audible only when the squelch circuit was turned off.

When the jammer was moved to a point 1/8 mile from terminal A the sound of the sweep was audible at both terminals whether the squelch was on or off, but the effect at terminal A was so strong that the operator at this terminal was unable to understand voice signals.

The AN/MLQ-8(XL-2) was then sited as shown in fig. 2B along a line perpendicular to the line-of-sight that passed through terminal A. At terminal B the sweep of the jammer was heard at all times and from all jammer sites, whether the squelch circuit was applied or not. The same was true at terminal A when the jammer was 1/4 mile away, but when the jammer was 1/8 mile away and the squelch was on, the sweep was not audible at terminal A.

When the jammer was sited 1/4 mile off the line-of-sight as shown in fig 2C, interference was negligible.

8. SUPPLEMENTAL TEST 4. INTERFERENCE WITH AN/MLQ-8(XL-2) OPERATION FROM RADIO TERMINAL SET AN/TRC-24

a. Purpose

The purpose of supplemental test 4 is to determine the degree to which division-area grid communications employing the AN/TRC-24 could interfere with the operation of the AN/MLQ-8(XL-2) when it is used as a countermeasure to 105-mm howitzer VT fuzes.

b. Procedure

The jammer was sited at 90-degree aspect to the trajectory of 105-mm howitzer VT fire at the jamming range of 9,000 yards, at which a kill of 70 to 90 percent could be expected, and the AN/TRC-24 was sited 10 miles away on the opposite side of the trajectory, directly opposite the jammer. The antenna of the AN/TRC-24 was directed at the AN/MLQ-8(XL-2), which was operating at 164 Mc/s, a typical fuze frequency.

At this relative location, the jammer became completely ineffective. To determine the distance at which the AN/TRC-24 would not share power with the AN/MLQ-8(XL-2) at this relative location, it would have been necessary to withdraw the AN/TRC-24 to successively greater distances until the power sharing ceased. Because of range limitations, a more practicable relocation was made. The AN/TRC-24 was resited in line with but behind the main axis of the lobe of the jammer, as shown in fig. 3.

The AN/TRC-24 was operated with a 1,000-cps tone on each of the 12 voice channels. The distance at which power sharing became effective through the back lobes of the AN/MLQ-8(XL-2) antenna was

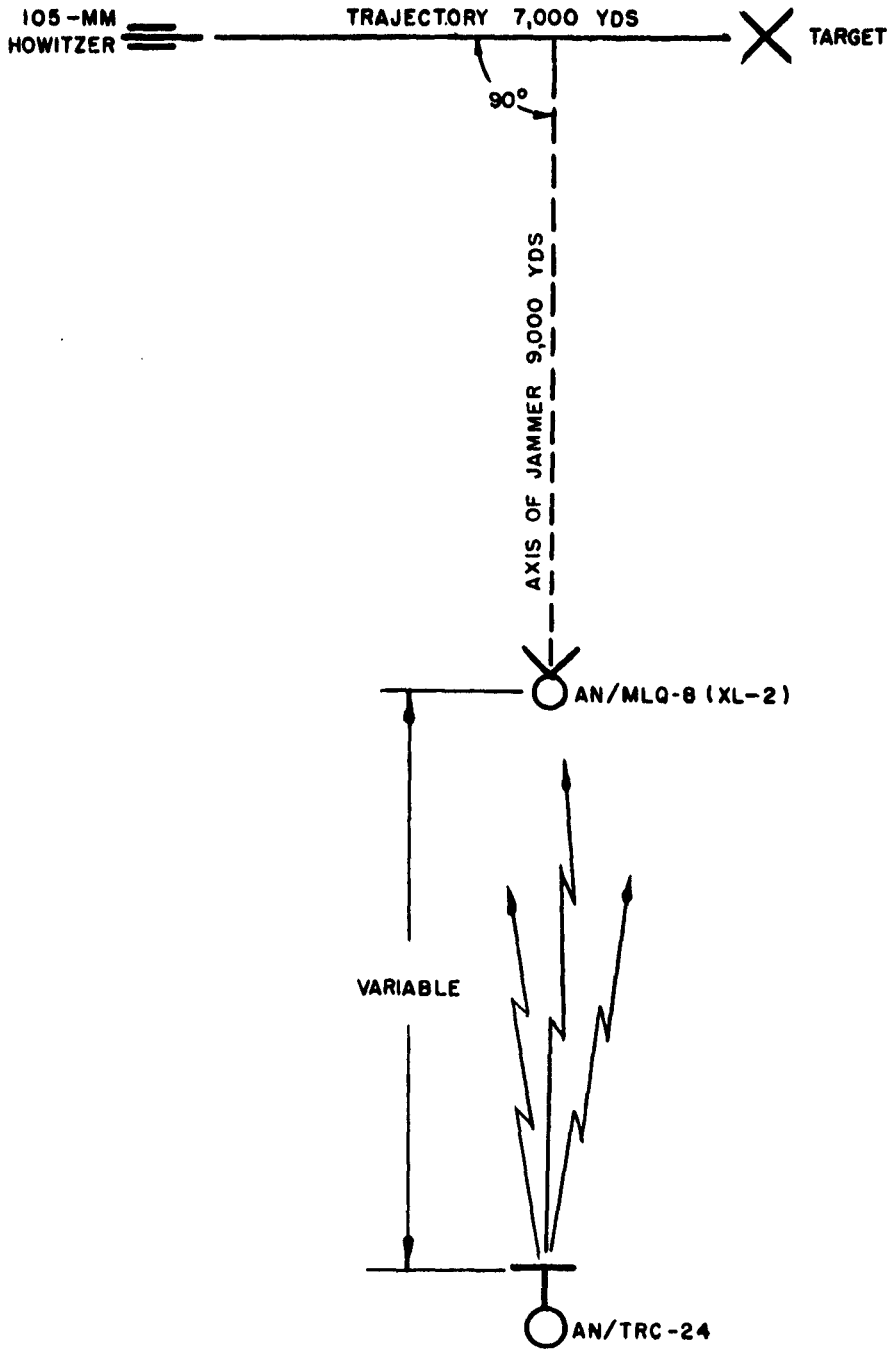


Fig. 3. Siting arrangement for Supplemental Test 4

determined. Field strength measurements of the AN/TRC-24 transmission were taken at the jammer antenna with the jammer antenna directed (1) at the AN/TRC-24, (2) 90 degrees away from it, and (3) 180 degrees away. The measurements were made through the antenna of the AN/MLQ-8(XL-2) with an NF-105 field strength meter.

Throughout the test the AN/MLQ-8(XL-2) used maximum power and employed the EDL folded-dipole antenna elevated 10 degrees and polarized at 25 degrees. It operated at two sweeps per second with a duty cycle of 1/5, and the squelch circuit was on continuously.

c. Test Results

The AN/MLQ-8(XL-2), without interference, obtained a kill of 90 percent at a jamming range of 9,000 yards. When the AN/TRC-24 was moved to successively closer positions from the rear, the jammer began power-sharing, and, when the AN/TRC-24 was situated within 6,400 and 8,100 yards, the kill dropped to 70 percent.

The inherent noise level at the AN/MLQ-8(XL-2) antenna was 16 uv. The actual field strength of the signal received from the AN/TRC-24 at the distance where interference began was calculated from the equation

$$S_t = \sqrt{(S_a + N)^2 - N^2} \qquad (1)$$

where S_t = true signal strength
S_a = apparent signal strength
N = inherent noise level of receiving equipment.

The readings were taken with the antenna of the AN/MLQ-8(XL-2) in three different orientations with respect to the AN/TRC-24: (1) directed toward the AN/TRC-24; (2) rotated from the first orientation horizontally 90 degrees; and (3) rotated horizontally an additional 90 degrees, or 180 degrees horizontally from the first orientation.

Substituting in equation (1) the apparent signal strengths at 8,000 yards in the orientations described, the true field strength of the AN/TRC-24 at the jammer antenna was calculated as shown in Table I.

Table I. Field Strengths at Specified Orientations of the Jammer Antenna

Orientation of jammer antenna (deg)	S_a (uv)	S_t (uv)
0	160	159
90	28	23
180	50	48

Since the field strength of a signal in microvolts varies directly with the distance from a point source of energy, assuming constant impedance characteristics along the path of transmission, the distance at which the AN/TRC-24 would interfere with the AN/MLQ-8(XL-2) when its transmission was "looking" down the axis of the main lobe of the jammer, as in orientation 1 (see Table I), can be estimated with a fair degree of accuracy. The field strength of the interfering signal must be the same as the true strength of the signal received when the transmissions of the AN/TRC-24 and the AN/MLQ-8(XL-2) are identical in azimuth, as in orientation 3 (see Table I). The distance at which interference will cease at orientation 1 is determined by the equation

$$D_1V_1 = D_2V_2, \quad \text{or} \quad D_2 = \frac{D_1V_1}{V_2} \tag{2}$$

where D_1 = distance (yds) corresponding to the 159-uv strength of the AN/TRC-24 with orientation 1,
V_1 = field strength (uv) at D_1 with orientation 1
D_2 = limit (yds) of interference by AN/TRC-24 at orientation 3
V_2 = field strength (uv) at D_1 with orientation 3.

In equation 2, substitute

$$D_2 = \frac{8{,}000 \times 159}{48} = 26{,}000 \text{ yds (approx)}$$

$$= 15 \text{ miles}$$

The main lobe of the AN/MLQ-8(XL-2) will, therefore, not be affected by the AN/TRC-24 if the equipments are sited more than 15 miles apart. By the same method it can be established that the side lobe of the jammer will not be affected unless the equipments are closer than 3,800 yards or 2.2 miles; and direct field measurements given in Table I show that the rear lobe will be free of

interference if the AN/TRC-24 is kept 3.6 to 4.6 miles away. In application of these test results, various factors must be taken into consideration. These values are, of course, variable because of the influence of weather and terrain. The test results were obtained for only one elevation and one polarization of the jammer antenna.

Section IV. Conclusions

1. Supplemental test 1 shows that although two AN/MLQ-8(XL-2) jammers cause mutual interference when facing each other, the interference is of such short duration and displays such frequency variation that jamming effectiveness is not appreciably reduced. The range of 1,000 yards, which was used in the test, is not a tactical range. In actual combat the jammers would probably be 2,000 yards apart or even farther. Since previous tests at these greater ranges with collinear antenna patterns demonstrated no reduction in the efficiency of the jammers, mutual interference does not create a tactical disability.

2. Supplemental test 2 shows that the AN/MLQ-8(XL-2) causes no serious interference with division-area grid communications as long as the jammer is positioned farther than 1 mile from all communications terminals. At distances of less than 1 mile the teletype circuits are seriously affected. Although no testing was performed with on-line unenciphered code devices, it is assumed from the results of the tests that have been conducted that these devices would be affected in much the same manner as the teletype circuits.

3. The results of supplemental test 3 show that the AN/MLQ-8(XL-2) will not cause critical interference with voice communications employing the ARC Type 12 radio set at distances greater than 1/4 mile. At such distances some interference exists but it is not serious enough to prevent communication.

4. Supplemental test 4 shows that the AN/MLQ-8(XL-2) loses effectiveness in jamming VT fuzes when the AN/TRC-24 is directed at the jammer, and that the AN/TRC-24 must be withdrawn 15 miles when the equipments oppose one another in the direction of transmission, or 2.2 miles to protect the side lobes of the jammer and approximately 4 miles to protect the rear lobe. Because of expected variations in terrain, weather, or parameters of the jammer, these values are considered to be nominal.